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THE EFFECTS OF A DUAL-LEVEL STIMULUS-WORD LIST ON THE OCCURRENCE OF CLUSTERING IN RECALL

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THE PROBLEM

This study is a continuation of a series of experiments (1,2,3) on the characteristics of higher order mediating processes as they effect organization in recall. These mediating processes are hypothetical constructs whose characteristics are inferred from the clustering occurring in the recall of stimulus-word lists. A randomized stimulus-word list comprising equal numbers of words in two or more categories is presented to subjects. Clustering is defined as the tendency on the part of the subjects to recall the stimulus-words in sequences of words belonging to the same operational category. The previous studies have demonstrated the effects on clustering of various types of reinforcement and of varying numbers of categories in the stimulus-word lists. The purpose of this study is to investigate the effects on clustering of the use of a stimulus-word list permitting the occurrence of clustering on two levels of organization.

In accounting for clustering we have made use of Hebb's (4) conception of the development of superordinate perceptions. According to Hebb, the repeated perception of a set of related elements or parts results in the emergence of a new structure, the superordinate system. Eventually the activation of a single perceptual element will suffice to arouse the superordinate system, which in turn will facilitate its subordinate perceptual elements. We may rephrase this conception in terms of our experiment. The perception or recall of a single word will tend to activate the superordinate systems corresponding to the categories to which the word belongs. We assume that such superordinate systems have been developed to varying degrees of functional capacity by pre-experimental learning. Once a superordinate system is activated, it will tend to facilitate the perception and recall of other words belonging to the same category. The previous studies in this program have investigated various experimental hypotheses which were developed from this conception.

Our method of investigating dual-level clustering was based on the use of a stimulus-word list comprising four major categories into which the words fell and by having each of these major categories contain two minor categories. Thus, we might have a major category of animals which contains the two minor categories, feline animals and canine animals. Clustering is thus possible on an animal-level, per se, or on both levels. In terms of the theory of superordinate structures, the animal-category would represent a higher-level superordinate system within which lower-level superordinate systems are possible, i.e., a feline system, a canine system, a mammal system, or a primate system etc.

With this type of design, we may assume each word is capable of activating at least three ordinate systems, namely, its own, its lower-level superordinate system, and its higher-level superordinate system. Our interpretation of Hebb's theory implies that the results obtained by using this type of design should have the consequence of stronger reinforcement of superordinate systems than would be expected if the design assumed the activation of only a single-level of superordinate systems. On the basis of these assumptions we have undertaken the present study in order to test the following general hypothesis.

> The use of a dual-level stimulus-word list should result in stronger reinforcement of organizational systems than would be expected for comparable single-level stimulus-word lists.

PROCEDURE

A stimulus-word list comprising 40 words was constructed. Of the 40 words, ten were animals, ten were countries, ten were names, and ten were weapons. Of the ten animals, five were canine animals and five were feline animals; of the countries, five were South American and five were European; of the names, five were male and five were female; of the weapons, five were shooting weapons and five were cutting weapons. With this particular design, the stimulus-word list could be considered as either or both of two alternatives: (a) a 40-word list with ten each of animals, countries, names, and weapons; (b) a 40-word list with five each of feline animals, canine animals, South American countries, European countries, male names, female names, shooting weapons, and cutting weapons. The first alternative would be a four-category list while the latter would be an eight-category list. It was thus possible to analyze the results of this one stimulus-word list on two levels of organization. All words were nouns and were chosen so that the mean Thorndike-Lorge (6) frequency-of-occurrence was approximately eight. The stimulus-words were randomized so that the occurrence of clustering or repetitions of words in the same categories was no more than chance would allow. Chance values of clustering or repetitions were derived from an artificial experiment which involved the drawing of random numbers to represent either a four or an eight-category, 40-word list. According to this artificial experiment the requirements of chance expectancy are met when an eight-category list has four repetitions and a four-category list has nine repetitions. Random numbers were again drawn and eventually a randomization was achieved which gave the required number of repetitions for both levels of organization. The randomized stimulus-word list was as follows:

> [(dagger, foil)], Belgium, mortar, spaniel, Rumania, Andrew, revolver, jaguar, Agnes, bayonet, Chile, musket, [(Susan, Elaine, Anna)], collie, [Oscar, Flora], leopard, lance, Brazil, carbine, Paraguay,

Wallace, [cutlass, pistol], [(puma, panther), husky], Hungary, Homer, Argentina, [bobcat, bulldog], [Peru, Portugal], terrier, Sweden, and Matthew.

The brackets indicate words clustered on the four-category level while the parentheses indicate words clustered on the eight-category level. The stimulus-words were printed on clear glass slides and were exposed by means of a Keystone overhead projector.

The subjects for this experiment were 50 undergraduate students at the University of Connecticut. They were given a simple set of instructions to the effect that a list of words would be projected one at a time on a screen and that after the projection they were to recall as many words as they could in the order in which the words occurred to them. The experimenter then exposed the stimulus-words at three-second intervals. The subjects were provided with data sheets upon which to record their recalled words. A total of ten minutes was allowed for recall.

RESULTS

The data were scored in the following manner. For each subject the individual words recalled were numbered and classified according to the categories to which they belonged. When this was accomplished, clusters or repetitions of words in the same category were bracketed and counted. For purposes of a more detailed analysis of the extent of clustering, each subject's recall-list was further broken down by the Vincent method into decile units, that is, the number of words in the first tenth of the recalled words, the second tenth, etc. By means of this breakdown it was possible to determine the occurrence of clustering in each decile and thus obtain a picture of the progressive changes in clustering occurring during recall.

In order to evaluate the results of this study, all analyses were compared with the results of a previous study by Bousfield and Cohen (3) in which a single-level four-category stimulus-word list, here referred to as 4-s, was given to one group of 50 subjects and a single-level eight-category stimulus-word list, here referred to as 8-s, was given to a different group of 50 subjects. In all other respects the make-up of the various stimulus-word lists was identical. It should be kept in mind that the dual-level list of the present study may be considered a four-category list and the analyses performed accordingly. On the other hand, the dual-level list may be considered as an eight-category list and the appropriate analyses performed at this level. Thus, the results of the dual-level list will be presented on two levels of analysis, a four-category level, 4-d, and an eight-category level, 8-d. Obviously, recall would be the same regardless of whether the dual-level list were considered a four-category or an eight-category list. For other results, differences were possible

because different bases of operation were used.

Several measures of the occurrence of clustering or repetitions were used in analyzing the data. The first measure was $r/N'-1$, where r represents the number of repetitions of words in the same category and N' represents the number of words recalled by a subject. The reason for using the term $N'-1$ in the denominator of this clustering measure was based on an empirical finding and a logical consideration. Referring to the artificial experiment again, it was found that the chance probability, p, of a repetition, could be closely approximated by the formula

$$p = \frac{W_c - 1}{N - 1}$$

where W_c is the number of words in a category of a stimulus-word list and N takes the value 40. If we are interested in the probability of repetitions in a subject's recall we would substitute r for W_c-1 and N' for N. Thus, we have the empirical reason for using $N'-1$ as a denominator term. The logical reason for $N'-1$ as a denominator term was based on the fact that in no case can the first word be considered a repetition since a repetition is by definition the successive occurrence of two words in the same category. The measure $r/N'-1$, as used here, was computed for each subject and then averaged.

Another measure of the extent of clustering was based on the expansion of the binomial $(p + q)^N$. Using the formula for p, from the last paragraph, a value of .231 was obtained for a four-category list and a p of .103 was obtained for an eight-category list. If these values of p are substituted in the binomial $(p + q)^N$ and the expression is expanded for values of N from one to 40, it is possible to generate a set of curves which will indicate how many repetitions, for a given N' are required for significance at the .05 and .01 levels. We have generated these curves and it is a simple matter to determine if a subject has sufficient repetitions for his given N' to be significant at the .05 or .01 levels. The percentage of the 50 subjects whose repetitions reached these levels of significance served as a measure of the extent to which the subjects exceeded chance expectation in their clustering.

A related measure was the degree to which clustering was instrumental in aiding recall. Sakoda (5) has shown that when individual differences are taken into consideration there is a high correlation between $r/N'-1$ and recall. If individual differences are not considered, the correlations are low but positive. We computed the correlations between $r/N'-1$ without the refinement of reference to individual differences.

The gross results of the dual-level analyses (4-d and 8-d) undertaken in this study are shown in Table 1 along with comparable

Table 1

Summary of Comparison Results

	Stimulus-Word List			
	4-d	4-s	8-d	8-s
Recall	18.06	15.62	18.06	17.64
r/N'-1	.36	.35	.22	.24
correlation between recall and r/N'-1	.30	.10	.29	.31
% sign. at .05	42	30	52	50
% sign. at .01	26	16	34	38

results for the 4-s and 8-s word-lists which were borrowed from our earlier study (3). It is obvious that the differences between the 8-d and 8-s results are as close as one could expect from two independent samplings. On the other hand, the comparisons for the 4-d and 4-s results imply that recall, correlation between recall and r/N'-1, and percentage of cases showing significant clustering are enhanced by having each major category broken down into two minor categories. While the difference for recall is significant at the .05 level, the differences for the correlation and for the percentage of cases showing significant clustering are not significant. Thus, we have some indication of greater reinforcement for the dual-level list. In this connection it is important to point out that results on the 8-d level will partially determine the results on the 4-d level but the reverse is not necessarily true. Thus, the sequence: leopard, husky, puma, terrier, and jaguar would be considered as four repetitions on the four-category level but there would be no repetitions on the eight-category level.

As already indicated, a different type of measure of the potency of clustering on the various levels of our analysis involved the determination of the progressive changes in clustering occurring during recall. Each list of recalled words was treated as follows. Omitting the first word of the list because it cannot be counted as a repetition, the remaining words were divided into decile units. The number of repetitions in each decile were then counted and divided by the number of words in the decile to provide the ratio r/n. These ratios were then converted by means of the following formula

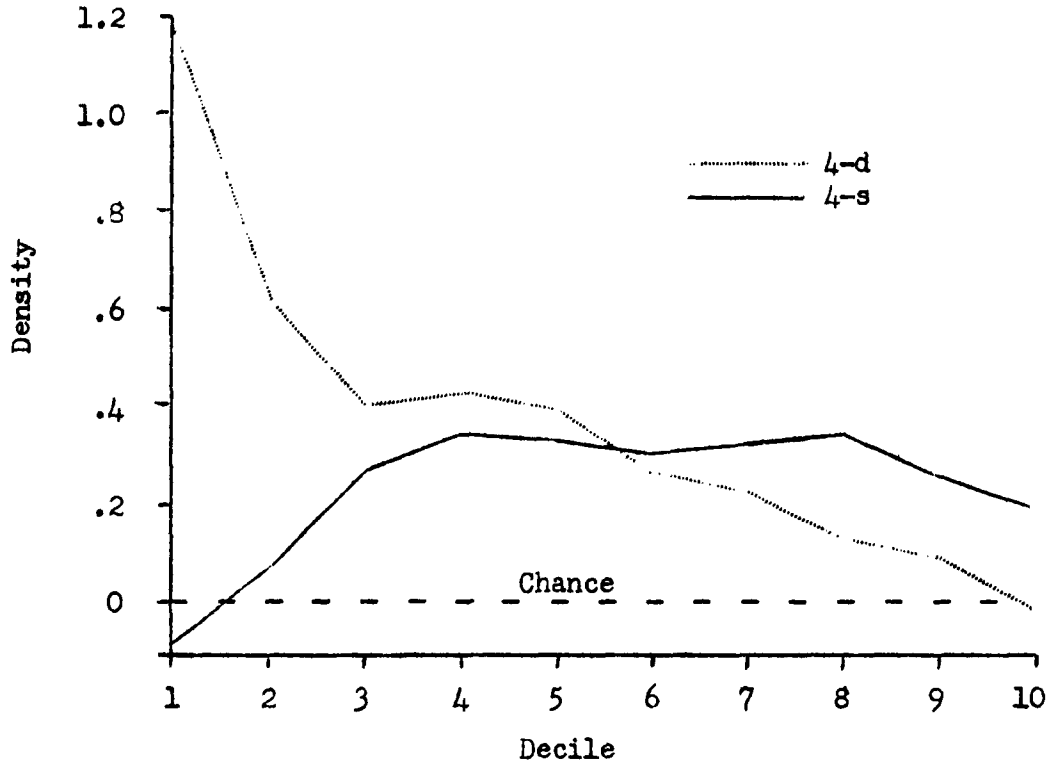
$$D = \frac{r/n - p}{\sqrt{pq}}$$

to provide an index, D, of the density of clustering per decile. In this formula, r/n has the value discussed above, p is the chance probability of a repetition based on a four-category list (.231) or an eight-category list (.103), and $\sqrt{pq}$ is the standard deviation of the p value. This measure is independent of N' and reduces both the four and the eight-category results to the same chance level, zero. The values plotted in Figure 1 represent running averages of the actual values of D. Several features of these plots are immediately evident. For both the 4-d and 8-d word-list breakdown, this measure starts initially high and rapidly drops towards chance. For the 4-s word-list, the measure is initially low, rises to a fairly stable value from the fourth to eighth decile and then shows a decline. For the 8-s word-list, the measure is roughly constant over the first four deciles and then declines towards chance. It is obvious that the density curves for 4-d and 8-d start at appreciably higher values than do their single-level counterparts. We account for these differences on the basis of greater reinforcement for the dual-level list.

DISCUSSION

As indicated in our introduction, we have undertaken to derive our experimental hypothesis from Hebb's account of the development of superordinate systems. We must assume our own responsibility, however, for our applications of his theory to the problem of clustering. For the sake of exposition we shall bring together the theoretical assumptions which we judge to be most relevant to the present experiment. They are as follows: (a) the repeated perception of related elements or parts results in the development of a superordinate system; (b) after sufficient development, a superordinate system may be activated by a single subordinate element and as a result of this activation the superordinate system will facilitate the action of other related subordinates; (c) lower-level superordinate systems may develop a subordinate relationship to higher-level superordinate systems; (d) any ordinate system will, when acitvated, tend to facilitate the action of both the superordinate and subordinate systems with which it is related; (e) with sufficient activation of a massed type, any ordinate system will become progressively less effective in its capacity to impart facilitation to its related superordinates and subordinates.

We may now apply these assumptions to the situation involved in our so-called dual-level stimulus-word list. As indicated earlier, each stimulus-word must activate at least three ordinate systems, namely, its own, its lower-level superordinate system, and its higher-level superordinate system. We may contrast this situation with that of our so-called single-level lists where clearly defined minor systems are lacking. Here the only consistent reinforcement is that which is given to the words themselves and to a single level of superordinates. The subject who has been presented a dual-level list will start his recall with a relatively high degree of strength in both his higher and his lower-level superordinate systems. On the other hand, the subject who has been presented a single-level list would start his recall with less highly reinforced superordinate systems. This accounts for the relatively high initial levels of clustering for the dual-level list. The rapid drop towards chance expectancy



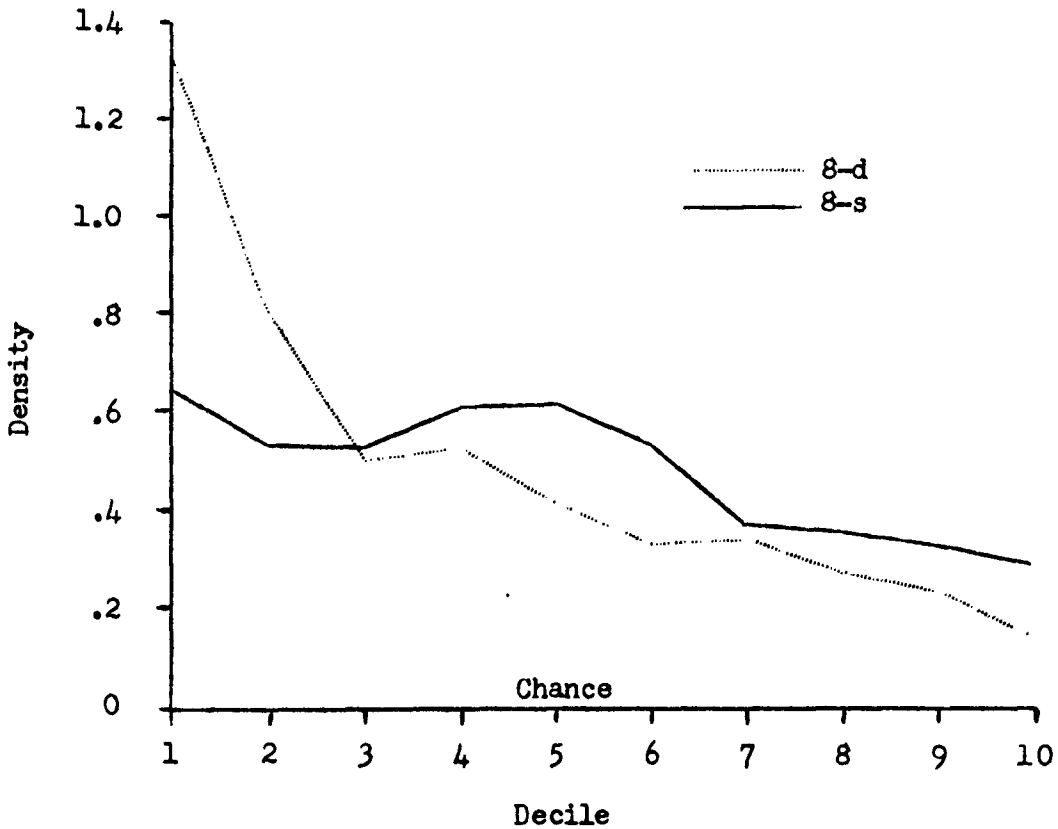


FIGURE 1

PROGRESSIVE CHANGES IN CLUSTERING DURING RECALL

shown in the decile analyses for both levels of the dual-level list may be explained as follows. Reinforcement of superordinates continues in recall and also continues to be greater for the dual-level list than for the corresponding single-level lists. This reinforcement has the consequence of massed activation which is sufficient, for the dual-level list, to impair the functional capacities of the superordinate systems and cause a rapid decline in clustering.

Thus it would appear that the strengths of ordinate systems resulting from the use of the dual-level list are primarilly effective in promoting clustering during the early stages of recall, but this effectiveness declines as recall progresses. As far as total clustering is concerned our results suggest that clustering on a major level is increased by the presence of clearly defined minor categories in the stumulus-word list. On the other hand, our results indicate that total clustering on a minor level is not increased by the presence of clearly defined major categories in the stimulus-word list. The general experimental findings are in support of our experimental hypothesis. We thus have indications of a positive relationship between the strengths of organizational systems and the levels of organization in the stimulus-word lists. The findings have implications for the manner in which material should be presented for efficient learning.

SUMMARY

A dual-level stimulus-word list comprising 40 words with ten each of animals (five feline and five canine), countries (five South American and five European), names (five male and five female), and weapons (five shooting and five cutting) was constructed and presented to 50 subjects. The analysis of the clustering occurring during recall of this dual-level stimulus-word list was performed on two levels, a four-category level and and eight-category level. The results were compared with the results of an earlier study where one list contained only four categories of words and another list contained only eight categories of words. The results support the following hypothesis.

> The use of a dual-level stimulus-word list should result in stronger reinforcement of organizational systems than should be expected for comparable single-level stimulus-word lists.

The findings are interpreted in terms of Hebb's account of the development of superordinate perceptions.

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